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(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
17 July 2003 (17.07.2003)

PCT

(10) International Publication Number
WO 03/058573 A1

(51) International Patent Classification[7]: G08B 21/18, 13/24

(21) International Application Number: PCT/GB02/05805

(22) International Filing Date: 19 December 2002 (19.12.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0200334.1 8 January 2002 (08.01.2002) GB
0226140.2 8 November 2002 (08.11.2002) GB

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(81) **Designated States** *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) **Designated States** *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW),

*[Continued on next page]*

# (54) Title: MAGNETIC INDICATOR


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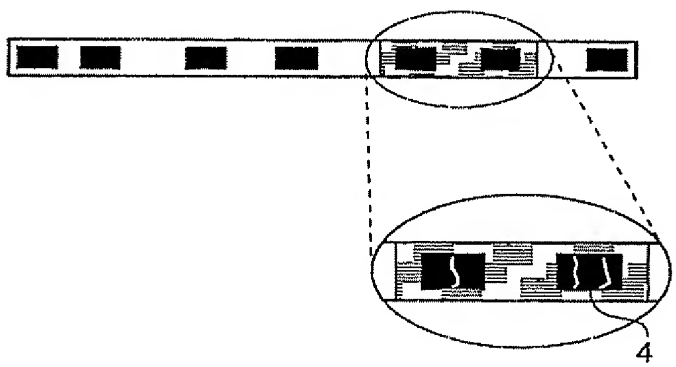


B

**(57) Abstract:** The present application relates to techniques for detecting if an article has previously experienced certain environmental conditions, such as temperature, shock, strain, which may be adverse to the proper functioning, quality or safety, of the article. There is provided a magnetic indicator comprising a plurality of magnetic elements (1) having remotely detectable properties arranged on a substrate (2). The substrate exhibits a known response to a predetermined change in one or more environmental conditions to which the indicator may be subjected, the response being such that the remotely detectable properties of at least one of the magnetic element(s) is permanently altered.

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Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

**Published:**
— *with international search report*

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# Magnetic Indicator

The present invention relates to an indicator which can be applied or used in conjunction with a wide range of products or consumer articles and which provides a means of remotely detecting if the indicator has previously experienced certain environmental conditions, as herein defined, which may be adverse to the proper functioning, quality or safety, of an article to which the indicator may be attached.

It is common for modern electronic consumer articles to be fitted with complex and often delicate components. These components can be sensitive to high and low temperatures and to shock. Examples of such devices are the LED displays used in portable electronic components such as watches, portable computing equipment and mobile phones.

In cases where the electronic article fails to function, either partially or totally, this failure may have been caused by the article previously experiencing adverse environmental conditions which are outside an acceptable operating/storage range, including: high/low temperatures and/or shock and/or water or chemical contamination. In such circumstances, for example, it would be advantageous for a manufacturer, retailer, supplier or end user to be able to establish what may have caused the failure, and thus where the liability for the article's malfunction falls.

There is also a need to ensure that frozen food products, such as meat or fish, have not exceeded a

given temperature. Furthermore, an ability to determine if an article which may comprise, amongst others, a food product, confectionary or electronic goods, has been exposed to water or water vapour, or contaminated by a given chemical, would also be desirable.

It would also be advantageous for the detection of adverse environmental conditions previously experienced to be ascertained remotely.

According to the present invention there is provided a magnetic indicator comprising a plurality of magnetic elements having remotely detectable properties arranged on a substrate, wherein the substrate exhibits a known response to a predetermined change in one or more environmental conditions to which the indicator may be subjected, the response being such that the remotely detectable properties of at least one of the magnetic element(s) is permanently altered.

Elements that have altered may advantageously produce a significantly reduced signal during interrogation of the magnetic tag by a suitable interrogation device. It therefore becomes possible to ascertain whether the tag, and thus the article to which it is attached, has previously been subjected to environmental conditions which may be adverse to the proper functioning, quality or safety, of an article to which the indicator may be attached.

Preferably, but not essentially, the magnetic properties of the magnetic elements are determined by subjecting them to a magnetic interrogation field

comprising, in a given direction, a high saturating magnetic field region, contiguous with a zero magnetic field region. Relative movement between the interrogation field and the magnetic elements of the indicator means that the elements, which are preferably formed of high coercivity, low permeability magnetic material (10000 henry per metre), are driven in and out of magnetic saturation. The magnetic permeability of the material advantageously exhibits a preferred axis of magnetisation so that when excited with an ac magnetic field parallel to the preferred axis of permeability, the magnetic of the material will comprise a non-linear function of the interrogation field, and will produce harmonics of the exciting field in regions where there is a zero tangential field. The presence of these harmonics will indicate the presence of the material so that a response signal can be obtained in which there exists a relationship between the time domain of the response and the spatial arrangement of the magnetic elements.

Advantageously, the magnetic elements are in the form of a thin film of less than 1 micron thick and which has a typical coercivity of less than 10 Gauss.

A detailed description of this technology, known as "Flying Null technology" can be found in WO 96/31790 the disclosure of which is incorporated herein by way of reference thereto.

Embodiments of the present invention which use tags that are based on Flying Null technology, such as those described in WO 96/31790, may be interrogated by

reading devices which use a magnetic interrogation field to which the elements will respond such as those described in WO 97/48990, WO 98/15851 and WO 00/39611. The disclosures of these documents is incorporated herein by way of reference thereto.

In one embodiment the substrate exhibits a temperature sensitive response so that when the ambient temperature to which the indicator is subjected falls outside (i.e. above or below) a predetermined range, the temperature sensitive response of the substrate causes at least one of the magnetic elements to fracture. This effect is observed as a result of the expansion/contraction of the temperature sensitive substrate in response to different temperatures. For example, the substrate may advantageously be designed so that it will contract less than the magnetic element, thereby causing that element to fracture.

The indicator of this embodiment may advantageously be manufactured so that the substrate is formed from more than one carrier material, each material having a different temperature sensitive response, so that the elements of the tag are mounted on different carrier materials. In this way, it is possible to determine if the indicator has previously experienced temperatures outside a number of different levels (e.g. 50C, 100 C) since the different materials will require different threshold temperatures to be exceeded before the material will have undergone an expansion sufficient to cause the fracturing of the overlaying element(s).

It may also be desirable to know when an article has been subjected to shocks which exceed certain predetermined levels, for example, as a result of the article being dropped, since the shock experienced by an article may have an adverse effect on the proper functioning of the article.

According to a further aspect of the present invention the substrate is provided with at least one fault line underlying one or more of the magnetic elements, such that when the indicator is subjected to a shock which exceeds a predetermined level, the substrate responds by fracturing along the at least one fault line thereby causing the one or more magnetic elements to fracture.

Thus it is possible to determine whether the indicator, (and thus any article to which it is attached), has experienced a shock exceeding a specified level.

In a similar way, the magnetic indicator can be arranged in proximity to a cap or seal, such that the substrate will fracture, thereby causing one or more of the overlying elements to fracture when the cap or seal is opened. This enables prior unauthorised tampering of a container or the like to be remotely detected without opening the cap or seal.

In a further embodiment the magnetic elements are mounted on a non-planar substrate, so that the elements are disposed on the substrate at varying angles relative to the plane of the substrate. When an indicator according to this embodiment is interrogated according to Flying Null technology by a magnetic field

comprising a high saturating magnetic field region, contiguous with a zero magnetic field region, the elements will emit a detectable response as they are driven in and out of saturation so that there will exist a relationship between the time domain of the response and the spatial arrangement of the magnetic elements including the angle of the magnetic elements. If the indicator experiences certain environmental conditions the profile or shape of the substrate may be altered, so that the relative positions or angles of the elements may be altered. Therefore, when the indicator is interrogated, the position at which the elements will respond to the interrogation field, and thus the time domain of the response, will have changed thereby enabling adverse conditions previously experienced by the indicator, such as shock or strain, temperatures outside a certain range or water/chemical contamination, to be to be detected.

Preferably, the indicator embodying the present invention can also function as an information carrier. For example, one part of the device may comprise a plurality of magnetic elements that are arranged on the substrate or carrier such that the spacing between them is used to represent a code. In this way, the label may advantageously be encoded with information about the article to which the label is to be attached, e.g. - manufacturer, supplier or cost. This can be particularly useful for verifying the authenticity of the article manufacturer, particularly if the information code is remains unaffected by changes in environmental conditions which may occur. This can be achieved by mounting the elements that are to form a

code on a part of the substrate which comprises material which is not significantly affected by changes in, amongst others, the temperature/shock/moisture. The magnetic properties of the elements themselves may also be used as a further means to encode information so that some, or all, of the elements has a unique attribute.

According to a further embodiment of the present invention, there is provided an indicator having a substrate which exhibits both a temperature sensitive response and which has a fault line. It is possible that this combined temperature and shock indicator can be augmented with a non-volatile identity (i.e. one that will not be lost should the indicator be subjected to temperatures and/or shock above a certain threshold) This non-volatile identity can be advantageously used to verify the article's authenticity and/or identity.

In some situations it may be desirable to be able to determine if a product, such as a food product or electronic article, has been exposed to water or water vapour. In an embodiment of the present invention there is provided a substrate which is arranged to absorb water or water vapour, such that the absorption of a predetermined amount of water or water vapour causes at least one of the magnetic elements to fracture.

In a further embodiment of the present invention, it is envisaged that the indicator is provided with a layer of material over the surface of the indicator elements. The overlaying material is advantageously arranged so that it will wear away, for example when exposed to

frictional forces, thereby exposing the underlying magnetic elements. Once the layer has worn away, the magnetic elements will continue to be subjected to any frictional forces, so that the response of the indicator will be substantially reduced. Such an embodiment cold be used to provide a remote non-contact indicator of tyre wear, for example.

For a better understanding of the present invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings in which:

Figures 1A and 1B show an indicator embodying the present invention comprising a substrate having a temperature sensitive response;

Figure 2 shows an indicator embodying the present invention comprising a substrate having a fault line;

Figure 3A and 3B show an indicator embodying the present invention having a non-planar substrate;

Figure 4 shows an indicator having a non-planar substrate which is interrogated by two readheads.

Figure 1 shows an indicator embodying the present invention and comprises a plurality of magnetic elements 1 supported by or incorporated in a substrate 2. The substrate 2 is provided with a carrier material 3 exhibiting a known temperature sensitive response. As the temperature changes from ambient, the elements 4, overlying the carrier material 3, will experience a

differential contraction or expansion due to the contraction or expansion of the underlying carrier material. The degree of contraction/expansion experienced by each of the elements will depend upon the properties of carrier material upon which the element is provided. If the carrier material undergoes a sufficient expansion, the element(s) will fracture, as shown in Figure 1B, thereby significantly altering the magnetic properties of the magnetic elements.

Elements that have fractured in this way will produce a significantly reduced signal during interrogation of the indicator by a suitable reading device. It therefore becomes possible to ascertain whether the indicator, and thus the article or product to which the indicator may be attached, has previously been subjected to temperatures which fall outside a specified range.

Figure 2 shows an embodiment of the present invention in which the indicator is provided with a substrate 21, having a fault line 23 underlying one of the magnetic elements 20. When the indicator is subjected to a shock which exceeds a predetermined level, the substrate responds by fracturing along the fault line 23 thereby causing the magnetic element 20 to fracture in a substantially controlled manner or in the vicinity of the fault line.

Figure 3A shows an indicator embodying the present invention in which a plurality of magnetic elements 30 are disposed on a non planar substrate 31, so that the elements are disposed on the substrate at varying

angles relative to the plane of the substrate. The indicator is interrogated by a read head 32 which generates a magnetic field comprising a high saturating magnetic field region, contiguous with a zero magnetic field region. When subjected to this magnetic field the elements will emit a detectable response as they are driven in and out of saturation. There will therefore exist a relationship between the time domain of the response and the spatial arrangement of the magnetic elements 30.

Due to the non-planar shape of the tag, there will be an error in the detected position of the magnetic element, an effect which can be most easily understood by reference to Figure 3B which illustrates the flux lines 41 being emitted from the magnetic readhead 32. A magnetic element will emit a detectable response when it is subjected to the null tangential component of the magnetic field. This will occur, in the case of an element 40 positioned so that it is perpendicular to the flux centre line 44 (i.e. parallel to the pole), when the tangential component of the field parallel to the element is zero. However, in the case of an element 41, which is not positioned parallel to the pole, there will be no response at the flux centre line since the component of the field tangential to the element will not be zero. Instead, a response is received away from the flux centre line at 41a where the flux lines are normal to the element (so that the tangential field along the element will be zero). Thus, a response is detected at 41a, for an element which is actually positioned at 41. The error x of the detected position will depend on the angle of the element away from

parallel. Thus, since the substrate is not flat, the angles of the elements relative to the plane of the indicator will vary, so that the response signals obtained from the elements of the tag will be different.

If the indicator experiences certain environmental conditions the profile or shape of the substrate may be altered, so that the relative positions of the elements will likewise be altered. Therefore, when the indicator is interrogated, the position at which the elements will respond to the interrogation field, and thus the time domain of the response, will have changed thereby enabling adverse conditions previously experienced by the indicator, such as shock or strain, temperatures outside a certain range or water/chemical contamination, to be to be detected.

If two readheads 50 and 51 are used as shown in Figure 4, each having a different magnetic centre line, then the estimated positions will be different for each reader. For example, the position determined by readhead 50 will be A and the position determined by readhead 51 will be B. It then becomes possible for the true position of the element to be determined by averaging the two positional estimates. Alternatively, the divergence in element positions measured by the two readheads can be used to measure the angle of the element. If the tag is put under strain the elements will straighten out, and the angles will change. Therefore, in this configuration the tag can be used to detect strain.

This method of using two readheads, each having a different centre line, may advantageously be used in a number of other applications which employ magnetic identification or coding techniques whereby one or a plurality of magnetic elements are supported on a substrate or article which may not exactly planar, or which has some surface discontinuities. The use of two readheads to determine the positions of the elements (and thus any information encoded by their relative positions) as described above, enables errors in the detected positions of the elements to be compensated for.

CLAIMS

1. A magnetic indicator comprising a plurality of magnetic elements having remotely detectable properties arranged on a substrate, wherein the substrate exhibits a known response to a predetermined change in one or more environmental conditions to which the indicator may be subjected, the response being such that the remotely detectable properties of at least one of the magnetic element(s) is altered.

2. A magnetic indicator as claimed in claim 1, wherein the substrate exhibits a temperature sensitive response.

3. A magnetic indicator as claimed in claim 2, wherein when the ambient temperature to which the indicator is subjected falls outside a predetermined range, the temperature sensitive response of the substrate causes at least one of the magnetic elements to fracture.

4. A magnetic indicator as claimed in claim 2 or 3, wherein the substrate comprises more than one material, each material exhibiting a different temperature sensitive response.

5. A magnetic indicator as claimed in any one of claims 2 to 4, wherein the indicator is applied to, or to the packaging of, a product such that the exposure of the product to temperatures which may have an adverse effect on the quality of that product, can be identified.

6. A magnetic indicator as claimed in any preceding claim, wherein the substrate is provided with at least one fault line underlying one or more of the magnetic elements, such that when the indicator is subjected to a shock which exceeds a predetermined level, the substrate responds by fracturing along the at least one fault line thereby causing the one or more magnetic elements to fracture.

7. A magnetic indicator as claimed in claim 1 or 6, wherein the indicator is arranged in proximity to a cap or seal, such that the substrate will fracture, thereby causing one or more of the overlying elements to fracture, when the cap or seal is opened.

8. A magnetic indicator as claimed in any preceding claim, wherein the substrate comprises a non-planar substrate, the magnetic elements being arranged on the substrate at different angles relative to the plane of the tag and wherein the substrate responds to the predetermined change in environmental conditions by altering its profile or shape, thereby altering the relative positions of the responses from the magnetic elements.

9. A magnetic indicator as claimed in any preceding claim, wherein the substrate is arranged to absorb water or other chemical contaminants.

10. A magnetic indicator as claimed in any preceding claim, wherein some or all of the magnetic elements are

arrange on the substrate such that the spacing between them represents a code.

11. A magnetic indicator as claimed in claim 10, wherein the magnetic elements which serve to encode information are supported by carrier material which is not significantly affected by the change(s) in environmental conditions.

12. A method of reading a magnetic indicator as claimed in any preceding claim, comprising i) subjecting the magnetic elements to a magnetic interrogation field comprising, in a given direction, a high saturating magnetic field region, contiguous with a zero magnetic field region, (ii) simultaneously applying a low amplitude ac magnetic field; (iii) causing relative movement between the magnetic interrogation field and the magnetic elements; and (iv) detecting harmonics of the applied ac field which are generated by the magnetic element as its magnetisation state is altered by passing through said zero magnetic field region.

13. A method as claimed in claim 12, wherein the method is carried out by means of a single read head which generates a magnetic interrogation field having a centre line.

14. A method of reading a magnetic indicator as claimed in claim 12, when applied to a magnetic indicator as claimed in claim 8, wherein the method is carried out by means of a first and second readhead, each readhead generating a magnetic field having a different centre line so as to allow for compensation in the error of the detected position of the elements on the non-planar substrate.

15. A magnetic indicator comprising a plurality of magnetic elements having remotely detectable properties arranged on a substrate, wherein the indicator is provided with a protective layer at least partially overlaying the magnetic elements, the layer being arranged so as to become worn away when exposed to frictional forces.

16. A magnetic indicator substantially as herein described with reference to the accompanying drawings.

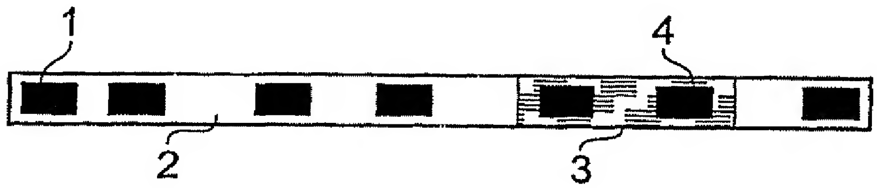


Fig. 1A

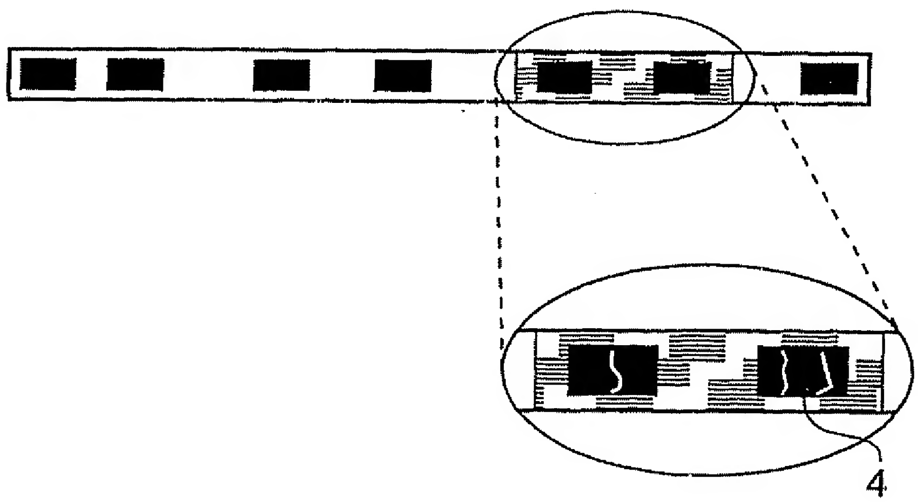


Fig. 1B

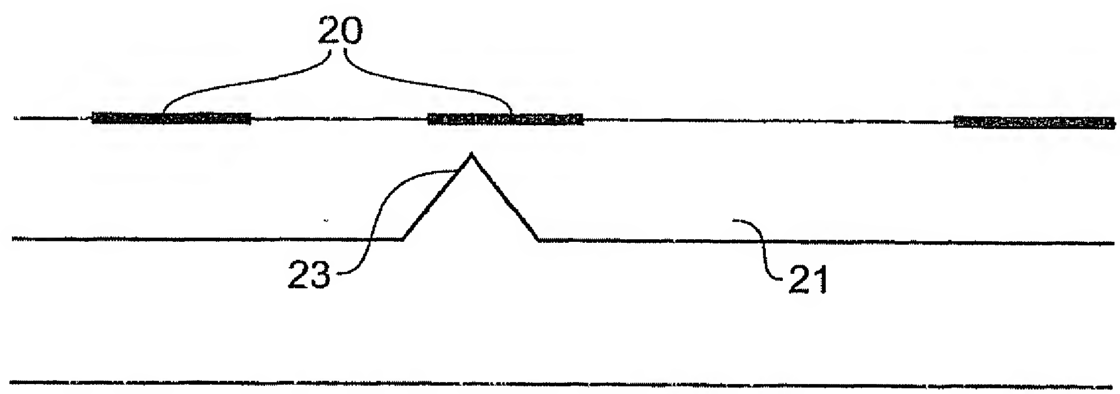


Fig. 2

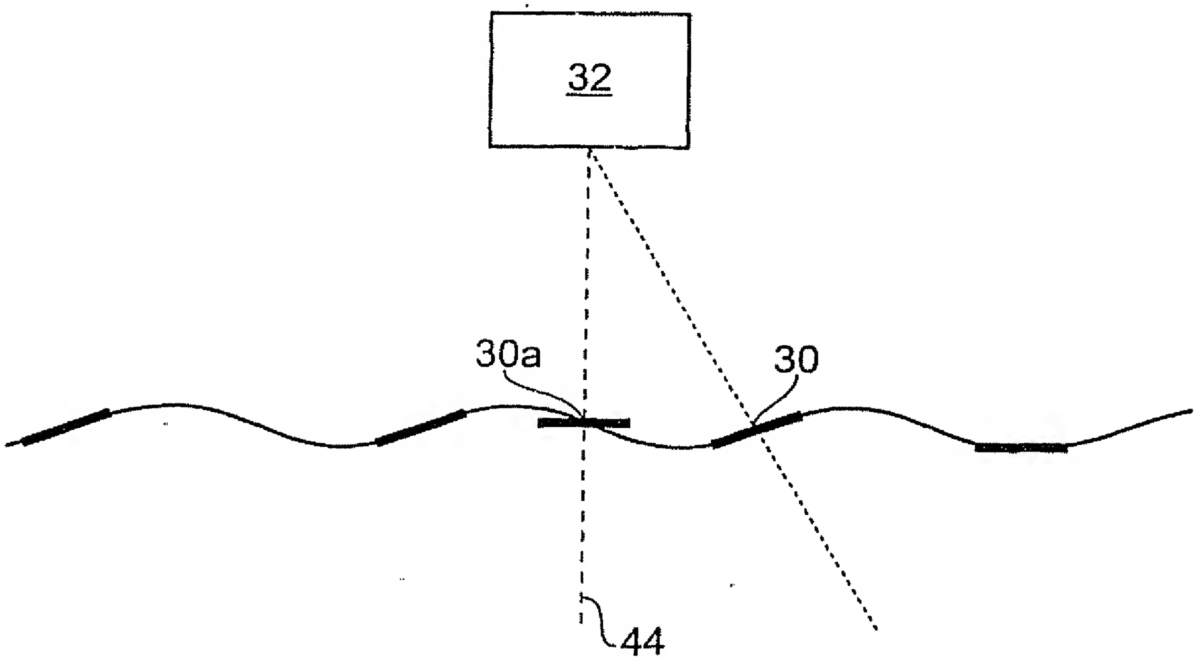


Fig. 3A

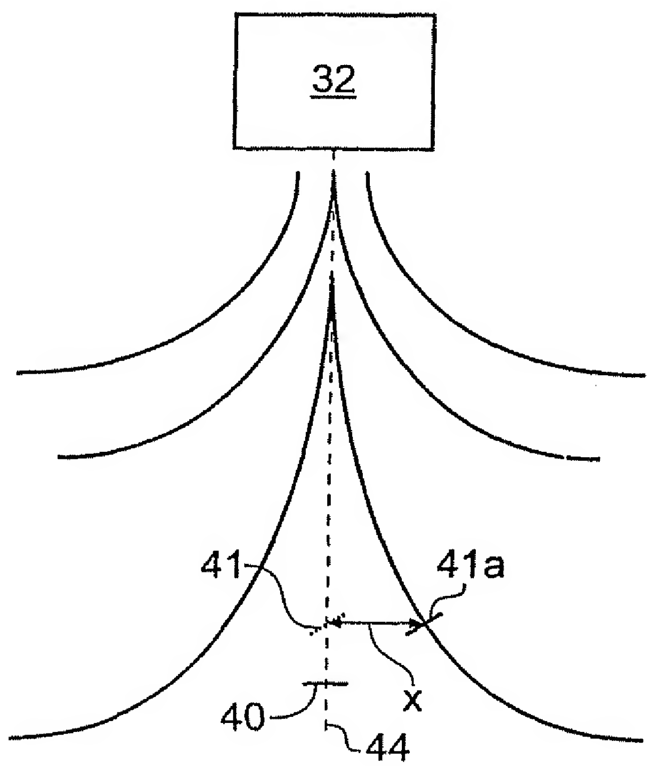


Fig. 3B

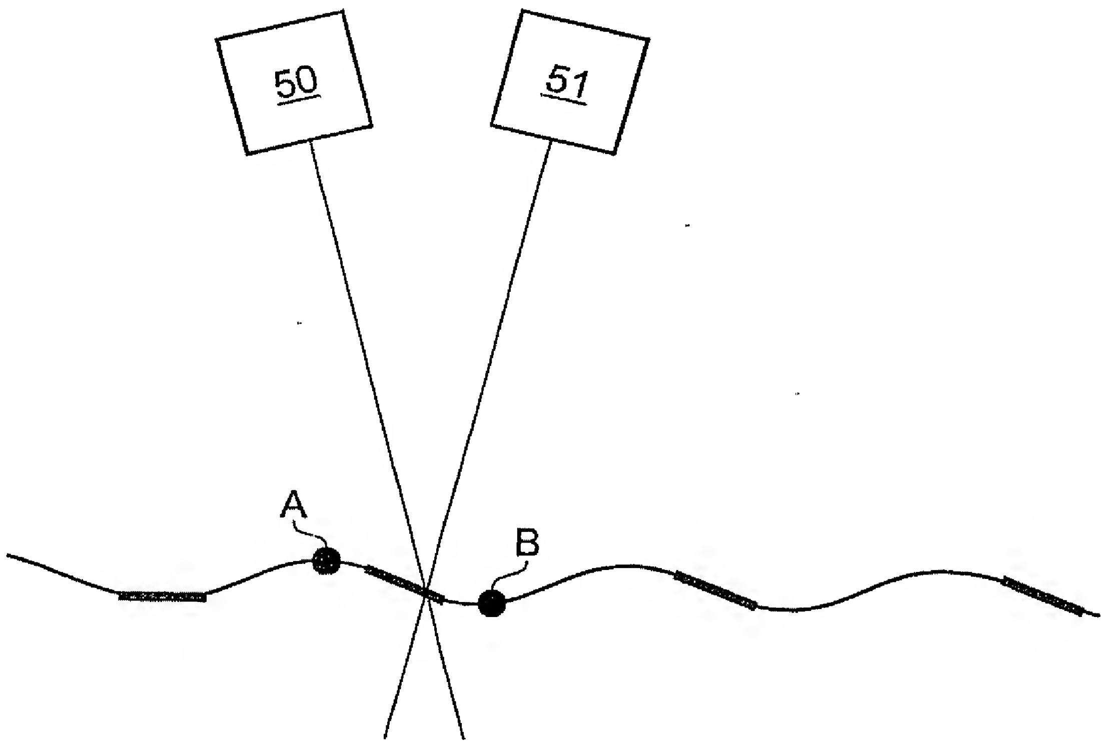


Fig. 4

# INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 02/05805

**A. CLASSIFICATION OF SUBJECT MATTER**
IPC 7 G08B21/18 G08B13/24

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G08B B65D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category ° | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
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☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

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| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 13 March 2003 | 20/03/2003 |

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Information on patent family members

Int...nal Application No
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